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Abstract

FUNDAMENTAL METALLURGICAL STUDIES FOR THE IMPROVEMENT OF METALLIC URANIUM FUEL ELEMENTS.

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This paper reviews the results of research work conducted by SNAM-LRSR into the metallurgy of metallic uranium fuel elements, and covers the study of uranium - rich niobium alloys in the range 0.2-7.2 wt % Nb and the intermetallic diffusion between uranium - titanium and titanium - Magnox AL 80 couples.

The use of uranium - rich molybdenum alloys in power reactor fuel elements stimulated research into the metallurgically similar uranium - rich niobium alloys, which have lower capture cross-sections. The analogy between these two types of alloy was examined by studying the kinetics and mechanisms of transformations occurring during interrupted quenching and continuous cooling from the γ and the $\beta + \gamma_1$ fields. The characteristics of the metastable phases obtained by water quenching from the γ phase and the Ms temperature vs. composition curves of the alloys have also been compared. Hardness and structural changes taking place during the ageing of the metastable α'_a and α''_b phases in uranium-niobium alloys are reported. With regard to irradiation experiments attention has been paid to the different structures obtainable in uranium-niobium alloys by various heat treatments and to the stability of these structures at reactor temperatures.

With a view to improving fuel element behaviour regarding heat

transfer and the mechanical properties of the can, the behaviour of titanium as a bonding element between uranium and Magnox AL80 has been studied using commercial purity materials. Results of metallographic examination and electron probe micro-analysis of the intermetallic diffusion occurring between couples of uranium-titanium and titanium-Magnox AL80 are reported. Uranium-titanium diffusion was studied in a single phase field and in a polyphase field of the equilibrium diagram. The results obtained indicate that the carbon present in uranium, plays an important role during the diffusion. In fact there is a tendency for the formation of agglomerates of titanium carbide in such a manner as to hinder the diffusion of titanium in uranium. The volume diffusion in these couples was accompanied by an intergranular component of diffusion, while anomalous grain growth occurred in the titanium probably as a result of stresses operating during the diffusion treatment. By means of a special electron probe micro-analysis technique it was possible to establish the existence of diffusion of titanium in Magnox AL80 and also evaluate the solid solubility limit.